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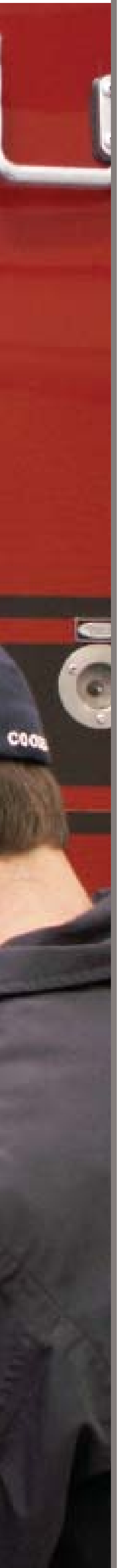

Noninvasive Measurement

A TRANSFORMATION IN PREHOSPITAL CARE USING THE PULSE CO-OXIMETER

>> BY JAMES J. AUGUSTINE, MD

What do firefighters, industrial workers, mine rescue workers, boaters and recreational vehicle users have in common? They're all readily susceptible to insidious cases of carbon monoxide (CO) poisoning.

The introduction of pulse oximetry and carbon monoxide oximetry is one of the most important advances in patient care technology. It allows emergency care providers to effectively detect and prevent premature death from CO poisoning. The introduction of such technology also fulfills the *EMS Agenda for the Future* and *National EMS Education and Practice Blueprint*, contingent on our ability to address scope of practice issues at each of the provider levels.

CARBON MONOXIDE TOXICITY

Carbon monoxide is a simple substance, and a ubiquitous byproduct of modern society. Ambient air contains a very small percentage of carbon monoxide, and it's formed whenever hydrocarbons are burned, such as when burning tobacco. In addition, the human metabolism of certain substances produces CO, including after the inhalation of paint strippers containing methylene chloride.

Once in the bloodstream, carbon monoxide binds to hemoglobin and to the parts of cells that metabolize oxygen. Hemoglobin that is occupied by carbon monoxide is called *carboxyhemoglobin*.

People who smoke or are exposed to secondhand smoke have elevated blood levels of carboxyhemoglobin (CO-Hb). In non-smokers, the normal level of carboxyhemoglobin can be up to 5%. People who smoke have normal levels of carbon monoxide up to 10%.[1]

Beyond these normal levels, CO is highly toxic. Dangerous concentrations can occur in the home, in an automobile, at a worksite, in commercial structures or even in the recreational environment. It's often an unexpected, fatal hazard for otherwise healthy individuals and can occur in clusters of people.[2]

CO poisoning results in hospital visits for about 50,000 persons per year and approximately 5,000 deaths per year.[3] This figure may be a low estimate, because widespread testing is not routinely performed.

Carbon monoxide may contribute to even more accidental deaths, masked by the poor judgment and clumsiness caused by CO intoxication, e.g., in waterskiing accidents in which carbon monoxide has poisoned the air behind a motorboat, cars left running in garages, or the firefighter injured at a fire scene.[4]

SCREENING FOR EXPOSURE

It's well understood that the longer carbon monoxide is in the body and the higher the levels, the worse the damage.[5] Recent evidence indicates that CO poisoning may contribute to a three-fold increase in cardiovascular morbidity long after the exposure event. Carbon monoxide reaches the highest levels in the cells of the most active organs in the body, namely the brain and myocardium. Permanent damage can occur in either organ system, with the potential for immediate death or premature morbidity and mortality.[6] Speed of detection, diagnosis and treatment limit those sequelae.

CO poisoning is under-recognized because until recently diagnosis has been dependent upon an invasive lab test. Such testing traditionally consisted of a blood test that measures the percentage of hemoglobin occupied by carbon monoxide instead of oxygen.

Carboxyhemoglobin is an unsuspected agent in many patients evaluated in the emergency system, whether in the field or the emergency department (ED). ED staff can order this test only for victims suspected of exposure, and CO poisoning has symptoms that mimic a large number of common diseases.

The lab test also has an expense, with charges to the patient that typically exceed $100. Therefore, widespread screening in EDs and other care settings has not occurred, and prehospital providers have previously had no tool available to do screenings.

In addition, the use of only pulse oximetry as an evaluation tool can falsely reassure the emergency provider that adequate oxygenation is occurring, even in cases of severe CO poisoning. Oxygen calculation algorithms in existing pulse oximeters, which analyze the infrared signals from the human body, mistake carboxyhemoglobin

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for oxyhemoglobin. Therefore, pulse oximetry may still show oxyhemoglobin levels near 100% when the patient is severely poisoned with carbon monoxide.[7]

One existing method of measuring carbon monoxide is a breath sampling with an inline detector. Using a method similar to measuring end-tidal CO_2, exhaled air can be analyzed and the partial pressure of carbon monoxide calculated, which correlates with the amount of carbon monoxide in the bloodstream, and subsequently in the alveoli, and then the exhaled air stream.[8] Use of the CO breath analyzer has not been widespread due to several practical limitations, including the need for frequent calibration with CO gas, the need for the victim to perform a 20-second breath hold and exhalation, and an analysis meter that's relatively expensive for single use.

However, a new tool featuring dynamic measurement of carboxyhemoglobin will add to our understanding of the pathology of CO poisoning. The pulse CO-oximeter, a noninvasive tool for measuring carboxyhemoglobin levels, is one of the truly remarkable additions to the health service armamentarium in the last decade. This device will allow more frequent screening by first responders and the discovery of subtle or unusual cases of poisoning. It received U.S. Food and Drug Administration (FDA) approval in 2005. With the introduction of this technology, the FDA approved the term SpCO as the measurement name, reflecting the saturation of carbon monoxide measured by pulse CO-oximetry.[9]

Table 1: Signs & Symptoms of CO Poisoning

CO-Hb	Severity	Signs & Symptoms
‹15–20%	Mild	Headache, nausea, vomiting, dizziness, blurred vision
21–40%	Moderate	Confusion, syncope, chest pain, dyspnea, tachycardia, tachypnea, weakness
41–59%	Severe	Dysrhythmias, hypotension, cardiac ischemia, palpitations, respiratory arrest pulmonary edema, seizures, coma, cardiac arrest
›60%	Fatal	Death

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BENEFITS OF CO ASSESSMENT

Now that we have an effective and timely intervention for CO screening and monitoring in the prehospital setting, several questions should be considered to maximize the overall efficacy of such monitoring.

How much carbon monoxide results in symptoms in what period of time? It will now be possible to record the rise in carboxyhemoglobin related to ambient concentration of carbon monoxide and the time of exposure. This will produce a graph of predicted carboxyhemoglobin levels, similar in utilization to a dive chart. See tables 1 and 2 for data related to time of exposure and symptoms of CO poisoning.

How fast do carboxyhemoglobin levels rise and fall when exposed to concentrations of CO? It has been reported that ambient levels of carbon monoxide at 100 parts per million will produce a carboxyhemoglobin level of 16% at normal pressures. This level will result in symptoms in most humans. Longer exposures will further increase the levels. Carbon monoxide being offloaded at tissues (e.g., the brain and heart) then leads to cellular toxicity, and further short- and long-term symptoms. For a skier and swimmer behind a recreational watercraft, for example, how long does it take to raise carboxyhemoglobin levels to the point where drowning is more likely?

Who is the unsuspected CO poisoning victim, and what is their source of exposure? In the field, there was previously no way to confirm CO poisoning, so exposure history and obvious symptoms have driven EMS treatment and transportation protocols. With the pulse CO-oximeter, first responders will be able to screen, confirm CO levels and make appropriate decisions regarding oxygen therapy and removal to facilities with hyperbaric oxygen treatment capability. Fire service responders will want to definitively locate the source of carbon monoxide that affected the patient. This is done so that the "chain of toxicity" is broken and both the original victim and others around that individual will be spared further exposure to the toxin.

Table 2: CO Sources & Exposure Levels

Source	Exposure (ppm)
Fresh Air	0.06–0.5
Urban Air	1–30
Smoke-Filled Room	2–16
Cooking on Gas Stove	100
Actively Smoking a Cigarette	400–500
Automobile Exhaust	100,000

Can we spare others from avoidable death or illness? Consider this scenario: A man dies in his home and is to be buried by his family. The family members travel to his city and stay in his home for the funeral events. Unfortunately, the man died of CO poisoning. His family was aware neither of the cause of death nor that the carbon monoxide came from a malfunctioning furnace at the home where they're now staying. Several more family members die as a result.

FIRE SERVICE IMPLICATIONS

Fire service personnel already use ambient carbon monoxide tools to assess certain emergency environments. They receive calls for assistance with identifying carbon monoxide in structures because of the alarm systems in commercial versions of CO ambient air meters. Their response includes an ambient air CO measurement tool, often combined with meters for other substances, that gauges the concentration of carbon monoxide and other toxins in the air. These ambient air meters are excellent tools for assessing air in closed spaces but aren't able to evaluate the environment as it was at the time the patient was in the setting.

Pulse CO-oximeters can check victims for obvious or occult poisoning with carbon monoxide. Combining the patient's pulse CO-oximeter results with the ambient air meter results will in many cases identify the poisoned patient and then the source. The pulse CO-oximeter reading can also identify cases where CO is *not* the primary toxin but other substances might be. The exposure victim with altered level of consciousness and low CO levels can be evaluated for cyanide toxicity, and specific treatment for that toxin can then be initiated.

The pulse CO-oximeter also has an important role in firefighter surveillance, particularly when combined with pulse oximetry and pulse, at active firefighting scenes. Firefighters have well-recognized sources of CO exposure, including inhaled products of combustion in a structure fire and exhaust from their vehicles or power tools. Because the pulse CO-oximeter combines the ability to measure pulse rate, oxygen saturation and carboxyhemoglobin level, rehabilitation operations can occur efficiently and firefighters capable of performing safely can be released back to duty from the rehab area.

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EMS IMPLICATIONS

Again, particularly when combined with pulse and pulse oximetry, pulse CO-oximetry will identify patients with symptoms potentially related to exposure. Many systems are likely to use the pulse CO-oximeter as an assessment tool for all patients with symptoms of general illness, headaches or "flu-like illnesses." Victim management can then be directed toward appropriate oxygen therapy. No doubt, this screening will eliminate the incidence of previously misdiagnosed flu-like illness. (See "'Every Patient' Protocol," p. 72.)

In addition, identification in the index patient allows proper protection and management of co-workers, friends or family who were also exposed. EMS providers can then use their own tools or collaborate with fire service personnel to find the source of the CO and prevent further harm to others.

In some incidents, the pulse CO-oximeter will be used to screen patients that don't need further therapy, haven't had significant CO exposure and won't need transport. This will allow people in the vicinity of a carbon monoxide release to be screened and then reassured that significant exposure has not occurred.

The application of pulse CO-oximetry in the field will also lead to appropriate transport decisions regarding hospital destination and the use of hyperbaric oxygen (HBO) therapy, as well as a protocol guide to the use of regional HBO chambers. It's uncertain in some of the medical literature whether HBO treatment is more effective than normobaric oxygen in preventing neurologic and other short- and long-term damage from CO poisoning. In any case, it's reasonable to expect that the pulse CO-oximeter may detect larger numbers of patients with CO toxicity, which in turn would allow a larger group to be treated and studied to determine which benefits from the hyperbaric versus normobaric variations.[10] It's also possible that continuous pulse CO-oximeter monitoring of the patient during normobaric therapy will predict those patients unlikely to benefit from a dive in the hyperbaric chamber.

To the EMS provider, it isn't the fire victim or the patient found unconscious at home who will benefit the most. These cases are already treated with the assumption of CO poisoning. It's the patient who presents to EMS personnel with flu-like symptoms and other non-specific symptoms that is at risk of misdiagnosis and subsequent bad outcome—for one or more people. EMS responders using the new tool would detect CO poisoning, treat the patient and put the wheels in motion to locate the poisoning source. Then EMS or fire personnel can screen other potential victims near the source, determining who needs to be treated and/or transported.


PHOTO GERT ZOUTENDIJK

CO screening of firefighters is crucial. Crews are exposed to sources of CO from structure fires and exhaust from their vehicles or power tools.

STEPS TOWARD IMPLEMENTATION

Each service obtaining a pulse CO-oximeter will need to draft patient care protocols that incorporate its use. Those protocols should indicate when to use the meter, what results are significant and what management steps will be used to treat the patient. The protocol should then specify that the source of the CO exposure needs to be sought and managed, and other at-risk patients or bystanders screened. Steps to protect others from further exposure need to be specified. This is the first tool that will specifically require the service and the EMS provider to look beyond the care of that individual patient. The protocol should also specify transport and destination decisions to be shared with the patient or family.

Rehab & firefighter surveillance: Fire and EMS agencies should draft rehabilitation and operating protocols regarding the use of the pulse CO-oximeter for screening of personnel, and then management. As noted, working in proximity to operating vehicles can produce elevated carboxyhemoglobin levels in our own emergency personnel. This screening process will help answer the question, "What

METERS APART

The pulse CO-oximeter will be used by EMS providers and firefighters as a tool in conjunction with the ambient air concentration meters to identify patients, sources of CO and ongoing hazards. As these pulse CO-oximeters are placed in service, potential issues could arise related to the various meters used for patient and environmental assessment. If we adopt a clear nomenclature for current and future devices, we can keep our names straight.

Air column oximeter: A device that uses samples of expired air from a human subject to measure the percentage of oxygen in the air column.

Ambient oximeter: A device that uses samples of environmental air to measure the percentage of oxygen.

Dosimeter: A device that measures a standard unit of radiation exposure. An additional word may add clarification to the method or site of acquisition.

End-tidal carbon dioxide detector: A device that uses samples of expired air from a human subject to measure the percentage of carbon dioxide in the air column.

Oximeter: A device that uses transcutaneous transmission and reception of light to measure the percentage of oxygenated hemoglobin in a convenient body site. An additional word may add clarification to the method or site of acquisition.

Pulse CO-oximeter: A device that uses transcutaneous transmission and reception of light to measure the percentage of carboxyhemoglobin and other dyshemoglobins in the blood, at a convenient body site.

Thermometer: A device that measures the temperature in a body site or orifice. An additional word may describe the method or site of temperature acquisition, such as tympanic thermometer or rectal thermometer.

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are the CO levels at emergency scenes, when all of our vehicle engines are running around us?" Such preventive measures may be able to reduce emergency ground falls, accidents and misjudgment. We might also reduce the "carbon monoxide headaches" that occur after operations requiring prolonged exposure to vehicle exhaust.

Public health & screening: Carbon monoxide poisoning is likely more dangerous to certain groups in the community, such as children and pregnant women.[11] Using pulse CO-oximeters, fire and EMS agencies, as well as health clinics and physician offices, could offer routine screenings of those groups of individuals to detect hidden cases of CO inhalation. Particularly in weather conditions conducive to CO poisoning, where hydrocarbon fuels are burned indoors for heating, screening may identify insidious cases and allow corrective actions to be taken.

SCREENING: TODAY & BEYOND

The technology of transcutaneous analysis for key substances and toxins will continue to expand, and we should expect more tools to be introduced. Naturally, the availability of such tools will result in questions regarding scope of practice for EMT-basics, intermediates and paramedics. State regulatory bodies will need to create language, training programs and review processes that will allow certain screening and diagnostic tools to be used by EMTs at the different provider levels.

The pulse CO-oximeter sets the stage for the types of protocols and management principles we'll need to apply. We should expect the tools to improve and anticipate additional light-technology methods designed to measure important substances in the body without blood draws. Such technology applications will allow us to revise our thinking about exposures, related diseases and occupational risks.

The pulse CO-oximeter also enhances programs and risk management programs. Identifying rescuers with CO levels higher than expected will reduce accidents and related safety issues. Civilian patients can be effectively screened and have carbon monoxide ruled out as a danger, and others in the area won't be unnecessarily transported. When occult cases are identified, injury or fatality can be avoided for one or multiple people. Those occult cases can be taken to definitive therapy, including hyperbaric oxygen where available.[12]

PHOTO A.J. HEIGHTMAN

Patients with flu-like symptoms may have undetected CO poisoning. Screening can identify those who may need further care. Bonus Web content: Go to jems.com to review a CO case you could be dispatched to manage.

In the future, it's possible that these tools will be developed for the commercial market and sold to worksites or people at risk, or even for use in the household. Pulse CO-oximeters might also be sold or rented for pregnant women to use at home. They'll be given instructions on use and levels for concern, and likely advised to call emergency services if results are elevated.

SUMMARY

The pulse CO-oximeter is a simple-to-use transcutaneous monitor that will improve prehospital care if applied with appropriate protocols; however, it will require providers to "think beyond the patient they're treating."

Adding this innovative new tool to your agency's protocols will help detect insidious cases of CO poisoning and prevent poisoning of others. It's a critical method for protecting both personnel and patients from the often-imperceptible danger of carbon monoxide.

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For more on CO, review a handout from Dr. Augustine's EMS Today session at www.jems.com/jems/32-5/.

REFERENCES

1. Hampson NB: "Emergency department visits for CO poisoning in the Pacific Northwest." *Journal of Emergency Medicine.* 16(5):695–698, 1998.
2. Hatlestad D: "Carbon monoxide poisoning: Incidence, diagnosis, & treatment." *EMS Magazine.* 34(10): 68–71, 2005.
3. Centers for Disease Control and Prevention: "Carbon Monoxide Poisoning." www.cdc.gov/nceh/airpollution/carbonmonoxide. Accessed April 3, 2007.
4. Bolstad-Johnson DM, Burgess JL, Crutchfield CD, et al: "Characterization of firefighter exposures during fire overhaul." *American Industrial Hygiene Association Journal.* 61(5):636–641, 2000.
5. Sokal JA, Kralkowska E: "The relationship between exposure duration, carboxyhemoglobin, blood glucose, pyruvate, and lactate and the severity of intoxication in 39 cases of acute carbon monoxide poisoning in man." *Archives of Toxicology.* 57(3):196–199, 1985.
6. Satran D, Henry CR, Adkinson C, et al: "Cardiovascular manifestations of moderate to severe carbon monoxide poisoning." *Journal of the American College of Cardiology.* 45(9):1513–1516, 2005.
7. Buckley RG, Aks SE, Eshom JL, et al: "The pulse oximetry gap in carbon monoxide intoxication." *Annals of Emergency Medicine.* 24(2):252–255, 1994.
8. Cone DC, MacMillan DS, VanGelder C, et al: "Noninvasive fireground assessment of carboxyhemoglobin levels in firefighters." *Academic Emergency Medicine.* 10(5):574, 2003.
9. Barker SJ, Curry J, Redford D, et al: "Measurement of carboxyhemoglobin and methemoglobin by pulse oximetry: A human volunteer study." *Anesthesiology.* 105(5):892–897, 2006.
10. Judge BS, Brown MD: "To dive or not to dive? Use of hyperbaric oxygen therapy to prevent neurologic sequelae in patients acutely poisoned with carbon monoxide." *Annals of Emergency Medicine.* 46(5): 462–464, 2005.
11. Longo LD: "The biologic effects of carbon monoxide on the pregnant woman, fetus, and newborn infant." *American Journal of Obstetrics & Gynecology.* 129(1):69–103, 1977.
12. Weaver LK, Hopkins RO, Chan KJ, et al: "Hyperbaric oxygen for acute CO poisoning." *New England Journal of Medicine.* 347(14):1057–1067, 2002.

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'EVERY PATIENT' PROTOCOL

CO SCREENING BECOMES STANDARD IN A RURAL CALIFORNIA COUNTY

>> BY JOHN ANDREWS, EMT-P

Paramedic Supervisor Shannon Hilderbrand evaluates a firefighter's carboxyhemoglobin level during her patient assessment regimen.

PHOTOS COURTESY TUOLUMNE COUNTY AMBULANCE SERVICE

Just a year after Tuolumne County (Calif.) Ambulance Service made a decision to use newly developed carbon monoxide (CO) detection technology to detect CO poisoning in multiple environments and situations, the new approach to patient assessment and screening is already paying dividends to the county's patients, residents and visitors.

A HISTORIC COUNTY

Famous for its gold-mining history, and home to Yosemite National Park, Tuolumne County is a popular tourist spot. Nestled in the Sierra Nevada mountain range in Central California, its population of just over 58,000 residents is scattered across 2,000 square miles of some of the state's most rugged terrain.

Many of Tuolumne County's inhabitants reside in extremely rural areas and use wood or gas to heat their homes. Thousands of campers make use of gas-fueled heaters and lighting devices, adding to the overall risk for CO poisoning. In order to screen patients suspected of suffering CO poisoning, Tuolumne County Ambulance Service, with the assistance of a grant from Masimo Corp., began planning to deploy Masimo Rad-57 Pulse CO-Oximeters prior to the onset of winter 2007.

THE CO DETECTION PROJECT

The increased risk for carbon monoxide poisoning, coupled with the nearly 100-mile distance to the closest hyperbaric center, presented a true need for EMS crews to determine if their patients had CO poisoning and the extent of the poisoning. Chief Operating Officer Bill Caldera, a 30-year EMS veteran, felt this new diagnostic tool would lead to rapid and accurate treatment, as well as assist crews in making transport destination decisions.

County EMS Coordinator Clarence Teem, along with County Medical Director Todd Stolp, MD, and the ambulance management team, developed policies and procedures for the CO detection project. This included a policy requiring all ALS ambulances to use a pulse CO-oximeter to measure blood carboxyhemoglobin levels of all patients in addition to their routine assessment of pulse oximetry.

In fall 2006, all EMTs and paramedics with Tuolumne County Ambulance Service attended mandatory training on CO poisoning and the use of the Rad-57 unit, which has the capability of monitoring both pulse oximetry and CO-oximetry through the same finger clip and the push of a single button.

The project was three-fold:

1. Screen all patients the ambulance service encountered for the possibility of CO poisoning;
2. Send an ambulance along with fire service units dispatched to residential and commercial carbon monoxide alarm activations and screen the building occupants for CO poisoning; and
3. Provide screening of firefighters for exposure to carbon monoxide secondary to smoke inhalation during or after firefighting activities.

The program was aimed at catching unsuspected cases of CO poisoning that might present as flu, chest pain, altered level of conscious, nausea or other common complaint in the community. The monitoring program also offered a unique opportunity for Tuolumne County Ambulance Service to play an active role in public health by screening the public for the most common form of poisoning and making an impact beyond one specific patient.

The program's "every patient" protocol required the EMS crews to monitor not only an affected or suspected CO patient but also unsuspecting occupants in the same building.

CO EXPOSED

In the early months after the program's implementation, Tuolumne County Ambulance crews discovered several cases of CO poisoning that would have been missed without the availability of the CO-oximeters. This included a number of patients transported from a correctional facility who had various complaints, but all presented with CO poisoning. As a result of the EMS findings, an investigation was launched that found and corrected the cause of the CO exposure.

One case involved a 58-year-old female who was seen in an emergency department (ED) after falling, striking her head and experiencing progressive dizziness for two days prior to calling for EMS. She was discharged without her CO exposure being identified. Her family reactivated 9-1-1 when her symptoms returned and then worsened.

During patient assessment, the responding EMS crew discovered the true cause of her dizziness and syncopal episode. The woman's carboxyhemoglobin was found to be 18%. She was treated and transported and the crew notified fire officials, who discovered the cause of the CO poisoning was high concentrations of carbon monoxide in her home.

Medic 41 is based in Groveland, Calif., near Yosemite National Park, and serves a highly rural population.

SCREENINGS FOR ALL

All Tuolumne County Ambulance patients now undergo carbon monoxide screening along with the use of pulse oximetry measurement. This proactive approach ensures that no patients slip through the EMS system undetected. It also offers a higher level of patient assessment when a CO exposure is detected, protecting other occupants in the same building who may not be aware that they've been exposed to high levels of carbon monoxide. This assessment regimen also prevents patients from dangers should the diagnosis of carbon monoxide poisoning be missed in the ED.

Rad-57 CO-oximeters were paired with Physio-Control LIFEPAK 12s on the service's ambulances.

Tuolumne County Ambulance Service also assists the county's fire personnel by screening firefighters for carbon monoxide at fire scenes, particularly during wildfire operations. Carbon monoxide can be a significant threat to wildland firefighters because a lesser level of respiratory protection is typically used by wildfire firefighters working on mountainsides than firefighters working inside a structure fire. The extended duration of smoke exposure to wildland firefighters also contributes to a higher exposure to carbon monoxide.

Recognition of CO poisoning at a fire scene allows EMS crews to provide prompt oxygen administration and flush much of the carbon monoxide out of the firefighters' respiratory system on scene, improving their long-term health.

Tuolumne County Ambulance Service has set the bar high with this innovative new program. It was a simple yet important step in improving the life of Tuolumne County's citizens and visitors, as well as protecting its first responders. JEMS

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LOCAL STATS

Tuolumne County emergency services are delivered by city, county, state and federal fire agencies, including Tuolumne County Ambulance Service, the county-operated agency that staffs ALS ambulances out of four stations. The Tuolumne County EMS Agency operates under a management contract through Manteca (Calif.) District Ambulance, a not-for-profit ambulance provider based in the adjacent county of San Joaquin.